

Two Realistic 40-Problem Structural Depth Exams

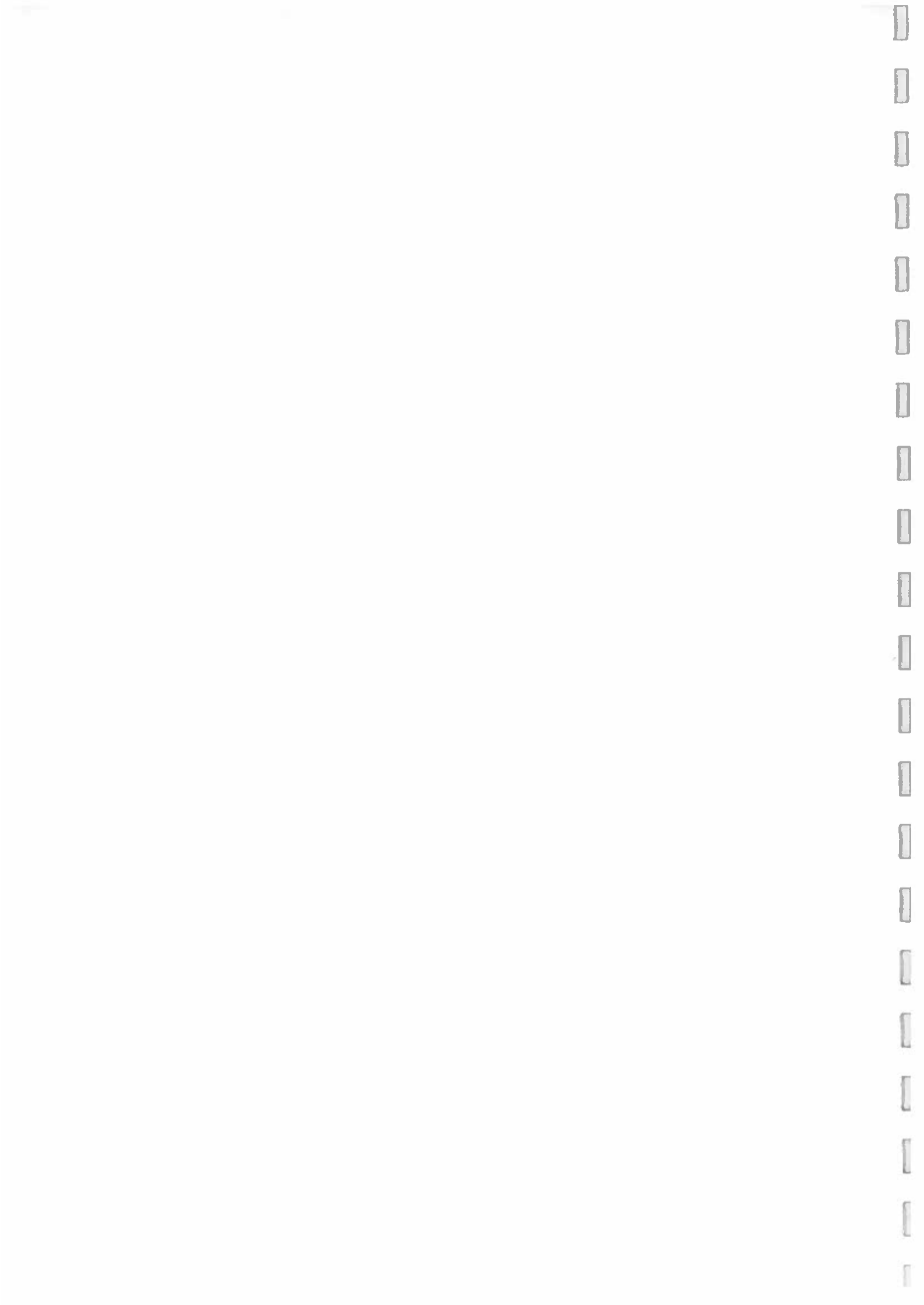
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Structural Depth Practice Exams for the Civil PE Exam

Second Edition

James Giancaspro, PhD, PE





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STRUCTURAL DEPTH PRACTICE EXAMS FOR THE CIVIL PE EXAM

Second Edition

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Preface and Acknowledgments

As a professor, I believe there are two approaches to learning: passive and active. An example of a passive method is the classic lecture, where an instructor recites theories, presents common engineering applications, and solves example problems. Active methods engage the students and motivate them to develop an in-depth knowledge of a subject. Active learning may include having students demonstrate equation derivations, using multimedia in the classroom, solving practical engineering problems, and performing interactive computer simulations.

The same approaches to learning apply to exam preparation. Passive preparation, such as reading or skimming reference books to familiarize oneself with relevant topics, can be effective for some examinees. However, I believe active learning is far more efficient and increases the potency of any preparation effort. Active preparation involves meticulously solving problems of varying difficulty that span a broad range of topics. At a minimum, an active approach forces examinees to navigate through relevant codes, familiarize themselves with their calculators, consciously connect relevant theories to problems, identify alternative problem-solving approaches, and consider how solutions can be influenced by changes in design parameters. This active approach to preparation is what I envisioned while writing this book.

During the months leading up to my PE exam, I found it difficult to locate solved practice problems that were representative of the civil PE structural depth exam. My motivation in writing *Structural Depth Practice Exams* was to provide examinees with a resource like the one I desired.

Over the course of many years, engineers in industry and academia have worked tirelessly to develop the specifications and codes that serve as this book's foundation. While it is impossible to acknowledge every individual's contribution to this book, I am deeply indebted to the many generations of engineers whose work has made this book possible.

Thank you to Julio C. Banks, MSME, PE, who technically reviewed the manuscript and offered suggestions to improve this book's clarity and accuracy.

I would also like to thank the entire PPI product development and implementation staff, including Sarah Hubbard, director of product development and implementation; Cathy Schrott, production services manager; Christine Eng, product development manager; Jenny Lindeburg King, associate editor-in-chief; Chelsea Logan, Magnolia Molcan, and Julia White, editorial project managers; David Chu, Ellen Nordman, Heather Turbeville, and Ian A. Walker, copy editors; and Kate Hayes and Tom Bergstrom, production associates, for their professionalism and guidance in producing this book.

If you find an error in this book, please let me know about it by using the error reporting form on PPI's website at ppi2pass.com/errata. I appreciate suggestions for improvement or clarification, as well as questions, so that new editions of this book will better meet the needs of future examinees.

I truly hope that you find this book beneficial to your exam preparation and wish you success in your future endeavors as a Professional Engineer.

James Giancaspro, PhD, PE

REPORT ON THE PROGRESS OF THE WORK

The work has been carried out in accordance with the programme of work approved by the Council at its meeting on 15th June 1961. The main items of work have been the study of the effects of the various factors mentioned in the programme, and the determination of the conditions under which the maximum yield of the product can be obtained. The results of the work are given in the following tables.

Factor	Yield (%)
Temperature	85
Time	90
Concentration	88

The results show that the maximum yield of the product is obtained at a temperature of 85°C, a time of 90 minutes, and a concentration of 88%. The yield is not significantly affected by the other factors mentioned in the programme.

Codes and References

The information that was used to write and update this book was based on the exam specifications at the time of publication. However, as with engineering practice itself, the PE examination is not always based on the most current codes or cutting-edge technology. Similarly, codes, standards, and regulations adopted by state and local agencies often lag issuance by several years. It is likely that the codes that are most current, the codes that you use in practice, and the codes that are the basis of your exam will all be different.

PPI lists on its website the dates and editions of the codes, standards, and regulations on which NCEES has announced the PE exams are based. It is your responsibility to find out which codes are relevant to your exam. In the meantime, here are the codes that have been incorporated into this edition.

STRUCTURAL DESIGN STANDARDS

AASHTO: *AASHTO LRFD Bridge Design Specifications*, Sixth ed., 2012, American Association of State Highway and Transportation Officials, Washington, DC

ACI 318¹: *Building Code Requirements for Structural Concrete*, 2008, American Concrete Institute, Farmington Hills, MI

ACI 530²: *Building Code Requirements and Specifications for Masonry Structures* (and related commentaries), 2008, The Masonry Society, Boulder, CO; American Concrete Institute, Detroit, MI; and Structural Engineering Institute of the American Society of Civil Engineers, Reston, VA

AISC³: *Steel Construction Manual*, Thirteenth ed., 2005, American Institute of Steel Construction, Inc., Chicago, IL

ASCE7: *Minimum Design Loads for Buildings and Other Structures*, 2005, American Society of Civil Engineers, Reston, VA

¹ACI 318 App. C solving methods may not be used on the exam.

²Allowable stress design (ASD) methods must be used on the exam, but strength design (SD) Sec. 3.3.5 may be used for walls with out-of-plane loads.

³Either ASD or LRFD may be used on the exam.

⁴The *Structural Welding Code* is not an NCEES design standard, but the structural depth specifications include AWS D1.1, D1.2, and D1.4 as design criteria likely to be encountered on the exam (see the Introduction).

AWS⁴: *Structural Welding Code—Steel*, D1.1, 2010, *Structural Welding Code—Aluminum*, D1.2, 2008, and *Structural Welding Code—Reinforcing Steel*, D1.4, 2011, American Welding Society, Miami, FL

IBC: *International Building Code*, 2009 ed. (without supplements), International Code Council, Falls Church, VA

NDS⁵: *National Design Specification for Wood Construction ASD/LRFD*, 2005 ed., and *National Design Specification Supplement, Design Values for Wood Construction*, 2005 ed., American Forest & Paper Association/American Wood Council, Washington, DC

PCI: *PCI Design Handbook: Precast and Prestressed Concrete*, Sixth ed., 2004, Precast/Prestressed Concrete Institute, Chicago, IL

REFERENCES

The following references were used to prepare this book. You may also find them useful references to bring with you to the exam.

"ACI 318-02 Beam Strain Limit of 0.004 versus 318-99 75% Balanced Steel." H. Epstein. *Practice Periodical on Structural Design and Construction*, Vol. 9, Issue 2

Bridge Engineering: Design, Rehabilitation, and Maintenance of Modern Highway Bridges. D. E. Tonias and J. J. Zhao. McGraw-Hill

Bridge Engineering Handbook. W. F. Chen and L. Duan. CRC Press

Design of Wood Structures—ASD/LRFD. D. E. Breyer, K. E. Cobeen, K. J. Fridley, and D. G. Pollock, Jr. McGraw-Hill

Ductile Design of Steel Structures. M. Bruneau, C. Uang, and S. E. Sabelli. McGraw-Hill

"Effective Flange Width Provisions for Composite Steel Bridges." I. Ahn, A. J. Aref, S. S. Chen, and M. Chiewanichakorn. *Engineering Structures*, Vol. 26

Engineering Economy. C. P. Koelling, W. G. Sullivan, and E. M. Wicks. Prentice Hall

Engineering Mechanics: Statics and Dynamics. A. M. Bedford and W. Fowler. Prentice Hall

⁵ASD methods for wood design must be used on the exam.

- Falsework Manual*. California Dept. of Transportation
- Foundation Analysis and Design*. J. E. Bowles. McGraw-Hill
- Handbook of OSHA Construction Safety and Health*. J. V. Eidson and C. D. Reese. CRC Press
- Handbook of Temporary Structures in Construction*. R. T. Ratay. McGraw-Hill
- "Investigation of the Kansas City Hyatt Regency Walkways Collapse." *Building Science Series 143*. National Bureau of Standards
- Masonry Design and Detailing*. C. Beall. McGraw-Hill
- MECAWind Software*. MECA Enterprises, Inc. mecaenterprises.com
- Mechanics of Materials*. J. M. Gere and B. J. Goodno. Cengage Learning
- Modern Welding Technology*. H. B. Cary and S. Helzer. Prentice Hall
- Prestressed Concrete: A Fundamental Approach*. E. G. Nawy. Prentice Hall
- Reinforced Concrete: A Fundamental Approach*. E. G. Nawy. Prentice Hall
- Reinforced Concrete Mechanics and Design*. J. G. MacGregor and J. K. Wight. Prentice Hall
- Reinforced Masonry Design*. W. L. Dickey and R. R. Schneider. Prentice Hall
- Seismic Design Manual*. American Institute of Steel Construction, Inc.⁶
- Simplified Design of Building Foundations*. J. E. Ambrose. John Wiley & Sons
- Soil Mechanics and Foundations*. M. Budhu. John Wiley & Sons
- Standard Handbook for Civil Engineers*. M. K. Loftin, F. S. Merritt, and J. T. Ricketts. McGraw-Hill
- Structural Analysis*. R. C. Hibbeler. Prentice Hall
- Structural Engineering Formulas*. I. Mikhelson. McGraw-Hill
- Structural Engineering Handbook*. C. Gaylord, E. Gaylord, and J. Stallmeyer. McGraw-Hill
- Structural Steel Design*. J. C. McCormac. Prentice Hall
- Structural Steel Designer's Handbook*. R. L. Brockenbrough and F. S. Merritt. McGraw-Hill
- "TEK Manual/Handouts." National Concrete Masonry Association. ncma.org
- The Wiley Dictionary of Civil Engineering and Construction*. L. F. Webster, ed. John Wiley & Sons
- Wind and Earthquake Resistant Buildings: Structural Analysis and Design*. B. S. Taranath. Marcel Dekker

⁶NCEES refers to the 2007 version of AISC 327 as the *Seismic Design Manual*, which encompasses AISC 327, AISC 341, and the 2006 supplement.

Introduction

ABOUT THIS BOOK

Structural Depth Practice Exams contains two civil PE structural depth exams designed to match the format and specifications defined by the National Council of Examiners for Engineering and Surveying (NCEES). Each 40-problem practice exam contains one problem per page, which is the same format as you will encounter on the civil PE structural depth exam. A step-by-step solution is provided for each problem. Each solution presents the correct path needed to arrive at the answer, along with relevant assumptions, illustrations, and explicit calculations. In some solutions, multiple approaches are shown so you can see alternative methods that may be used to solve the problems. Some solutions also include author commentary that uses the following icons for quick identification.

- ◆* common pitfall or distractor
- ⌚ technique or approach to reduce problem-solving time

Read the commentary to help streamline your problem-solving approach and avoid making simple mistakes during the exam.

The solutions in this book are consistent with exam-approved solving methods, as outlined in the NCEES specifications. You should work within these constraints while taking these practice exams. Steel problems on the exam can be solved using either the ASD or LRFD methods. This book gives ASD values followed by LRFD values in parentheses, and problems are solved using both methods. For concrete problems, ACI 318 App. C solving methods may not be used on the exam. Therefore, all concrete problems in this book are solved using ACI 318 Chap. 9 methods.

As you are working problems, be aware that this book distinguishes between unit weight (given as γ in units of lb/ft^3) and density (given as ρ in units of lbm/ft^3), while ASCE7 does not. In addition, for all problems relating to moments, assume that positive rotations are counterclockwise unless otherwise specified. For illustrations, the x - and y -axes are assumed to be positive and in the customary directions (i.e., the x -axis is horizontal, and the y -axis is vertical).

ABOUT THE EXAM

The civil PE exam is made up of 80 problems and is divided into two four-hour sessions. Each session

presents 40 multiple choice problems. Only one of the four options given is correct, and the problems are completely independent of each other.

The morning session of the civil PE exam is a broad exam requiring knowledge of five areas of civil engineering: construction, geotechnical, structural, transportation, and water resources and environmental. All examinees take the same morning exam.

Examinees must choose one of the five afternoon exam sections: construction, geotechnical, structural, transportation, or water resources and environmental. The structural depth section of the exam is intended to assess your knowledge of structural engineering principles and practice. The topics and approximate distribution of problems for the structural depth section are as follows.

1. Loadings (12.5%):
dead loads; live loads; construction loads; wind loads; earthquake loads, including liquefaction; site characterization, and pseudo-static analysis; moving loads; snow loads; impact loads; load paths; load combinations
2. Analysis (12.5%):
determinate analysis; indeterminate analysis
3. Mechanics of Materials (12.5%):
shear diagrams; moment diagrams; flexure; shear; tension; compression; combined stresses; deflection; progressive collapse; torsion; buckling; fatigue; thermal deformation
4. Materials (12.5%):
concrete (plain, reinforced); concrete (prestressed, post-tension); structural steel (structural, light gage, reinforcing); timber; masonry (brick veneer, CMU); composite construction
5. Member Design (25%):
beams; slabs; footings; columns; trusses; braces; frames; connections (bolted, welded, embedded, anchored); shear walls; diaphragms (horizontal, vertical, flexible, rigid); bearing walls
6. Design Criteria (12.5%):
International Building Code (IBC); American Concrete Institute (ACI 318, ACI 530); Precast/Prestressed Concrete Institute (PCI Design Handbook); Manual